Netherlands Experience in in-situ remediation

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- BioSoil
- In-situ remediation
  - principles
  - approach

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THE NETHERLANDS EXPERIENCE WITH IN-SITU REMEDIATION

In the early days of the discovery of soil pollution in the Netherlands it was assumed, that a maximum of about 700 sites would be present and excavation was advocated as a radical solution for these problems. Now many thousands of sites have been discovered and excavation alone would be so costly that most sites would never be decontaminated at all. The economic pressure allowed other techniques to be developed among which biological ones both after excavation (landfarming) and in-situ.

In the meantime an increasing number of chemicals was found to be biodegradable. Mainly because more attention is paid to biodegradation and other degradation routes but not in the least because micro-organisms seems to induce the ability to degrade chemicals after a prolonged exposure to these substances. So the necessary micro-organisms are in almost all cases present in the soils to be treated and extra measures to introduce degraders are, therefore, very seldom needed.

It now seems strange that huge quantities of inherently biodegradable materials pollute soils for almost infinitive times. The reason is that one or more of the pre-requisites for microbial growth are not met. Active biological decontamination, therefore aims at changing the soil conditions in such a manner that microbial growth is feasible and biodegrada-tion of the pollutants can take place.

In general this can be obtained by:

- improving the nutrient status of the soil;
- supplying oxygen or an electron donor in sufficient quantities;
- controlling the soil humidity;
- increasing the bio-availability of the contaminants.

The Netherlands experience will be elucidated for the remedia-tion of:

- petrol stations and tank parks;
- wood preservation sites (gas works);
- dry cleaning and metal degreasing (PCE and TCE).

Emphasis will be placed on the degradation of hydrocarbons, poly-aromatic hydrocarbons and chlorinated compounds such as pentachlorophenol under aerobic conditions and on the anaerobic dehalogenation of PCE under anaerobic conditions.

A far going reduction of contaminant levels can be obtained. Risks are reduced also. The general policy followed in the Netherlands for judging the final results of a remediation is discussed in relation to the general remediation practices.

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Problem areas

- Hydrocarbons / aromatic compounds
- PAH’s
- Chlorinated phenols
- Arsenic
- Chloro-ethenes (PCE, TCE)
- Leachates / methane

- ➢ petrol stations / tank parks
- ➢ wood preservation
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- ➢ dry cleaning / metal works
- ➢ landfills

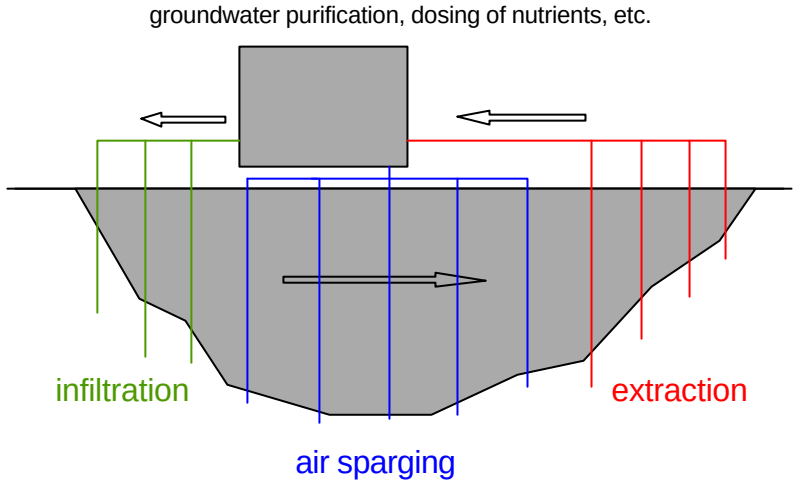
Biodegradation of contaminants

Prerequisites

- Presence of the appropriate micro-organisms
- Oxygen or an electron donor
- Nutrients
- Availability of the contaminants

Approach

- Extraction, purification and reinfiltration of groundwater
- Addition of nutrients or electron donor
- Aeration
- Adequate design of the in-situ system based on soil structure



for clarity the systems for extraction, infiltration and sparging are given separately ; in practice these are alternated

Hydrocarbons / aromatic compounds

Petrol stations / tank parks

Properties

- float on water
- water solubility
  - Hydrocarbons low
  - aromatic compounds high
- low vapour pressure for heavier compounds
- bind to organic matter
- biodegradable under aerobic conditions

Remediation

Properties

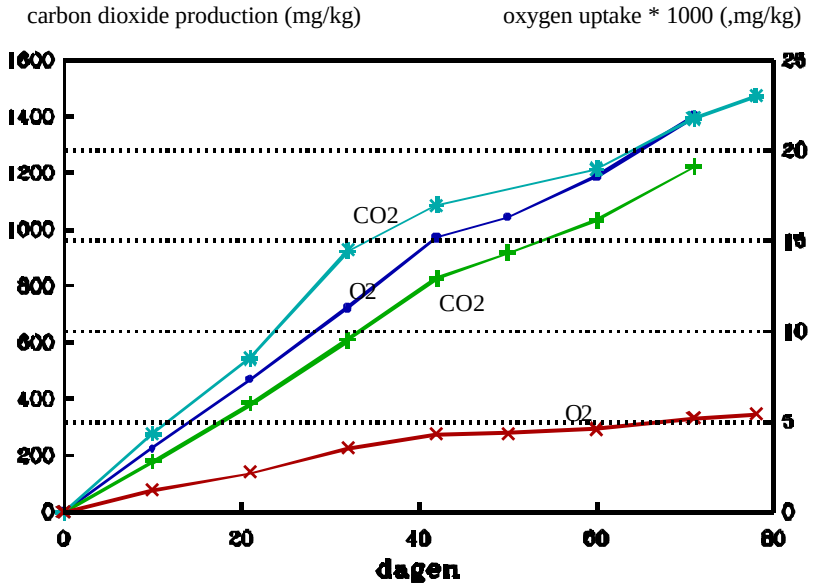
- micro-organisms normally present
- aerobic conditions
- sufficient nutrients
- mass transfer is rate limiting

Bus station

Properties

- Considerable losses over the years of about 25 tons diesel
- Smear zone of about 2 m
- Free product

Identification of possible problems



- nutrient status of the soil
- extreme concentrations (30.000 mg/kg)

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Results

- 5 tons of product removed physically
- 20 tons biodegraded
- residual levels below 500 mg/kg in soil
- groundwater levels below 50 g/l

Creosote

Wood preservation

- composition PAH’s, hydrocarbons, phenols
- partly lighter partly heavier than water
- apart from naphthalene and phenols: low
- strong adsorption on soil organic matter
- biodegradable under aerobic conditions

Creosote

Wood preservation

SOIL	TEST PERIOD (days)	Levels before degradation (mg/kg)		Levels after degradation (mg/kg)	
		PAH's	mineral oil	PAH's	mineral oil
Oostdijk A	392/374	3300	5900	89/84	140/330
Oostdijk B	392/188	5000	15000	77/110	430/760
Oostdijk C	441/441	9700	18000	43/33	250/210

Remediation

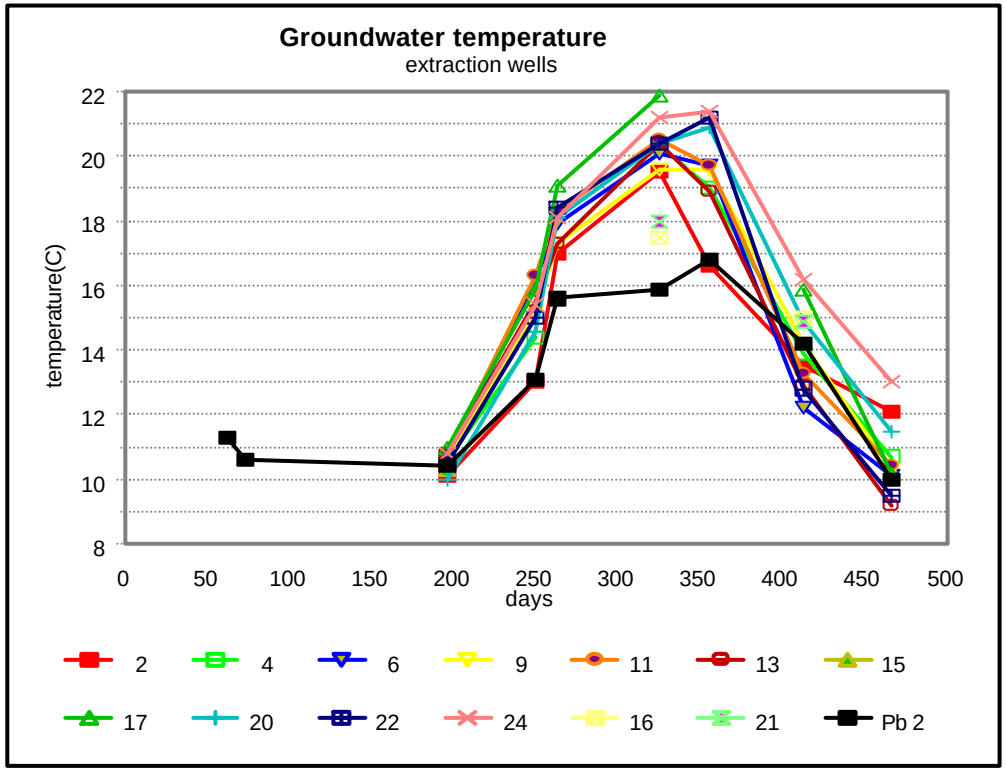
- Micro-organisms normally present
- Aerobic conditions
- Sufficient nutrients
- Mass transfer is rate limiting
- Removal of free product

Pilot test / full scale

- Size 400 m^2 / 10.000 m^2
- Depth 10 - 12 m-ss
- Duration 2 years
- System
  - extraction / infiltration at two depth
  - aeration (sparging) at two depth
  - spacing 5 m
  - product extraction system at 10 - 12 m-ss

Results

- Temperature rise
- 5 tons of product extracted
- At present 1 ton/week



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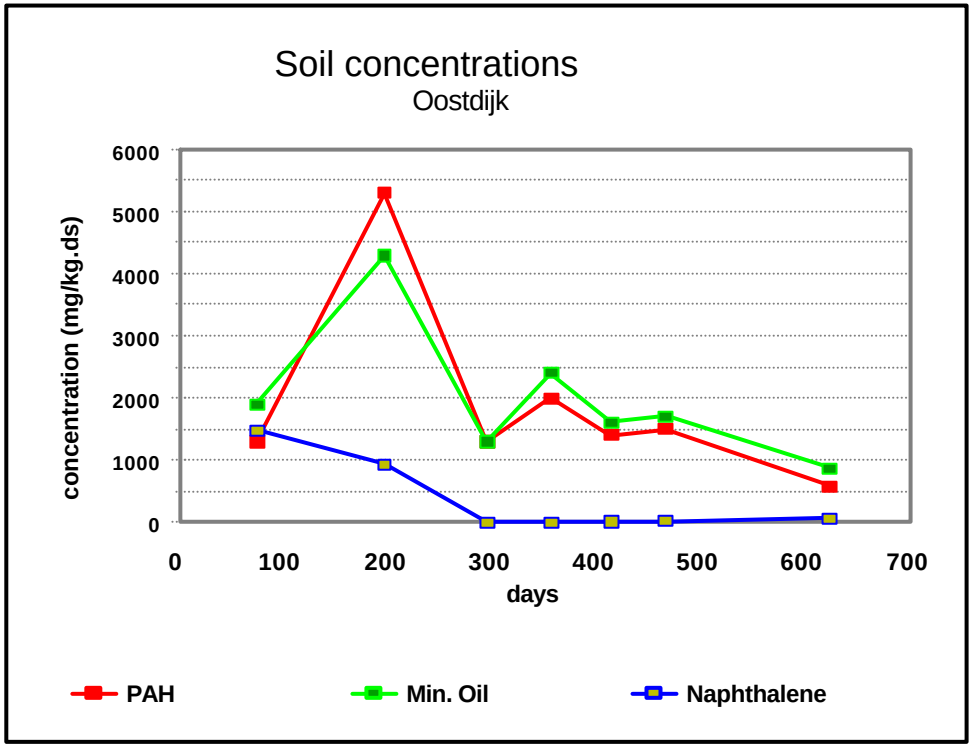
Results

- Low residual levels in both soil and groundwater
- Patchy distribution



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Pilot test / full scale

- Test results were used to design the full scale remediation
- Approved by the competent authorities

Chlorinated phenols

Wood preservation

Properties

- Soluble in water (pH dependent)
- Bind to organic matter
- biodegradable under aerobic conditions

Chlorinated phenols

Wood preservation

compound	duration (weeks)				
	0	3	9	19	40
pentachlorophenol (mg/kg)	**12**	**8.1**	**0.5**	**0.5**	**0.15**
monochlorophenols (mg/kg)	1.9	n.d.	n.d.	n.d.	n.d.
dichlorophenols (mg/kg)	4.7	0.62	0.1	n.d.	n.d.
trichlorophenols (mg/kg)	5.9	1.8	0.23	0.098	0.044
tetrachlorophenols (mg/kg)	6.8	1.7	0.17	0.11	0.041
total chlorophenols (mg/kg)	**31.30**	**12.22**	**1.00**	**0.77**	**0.24**

Arsenic (As)

Wood preservation

- Solubility depends on pH and redox conditions
- Removal in a pilot project about 90%

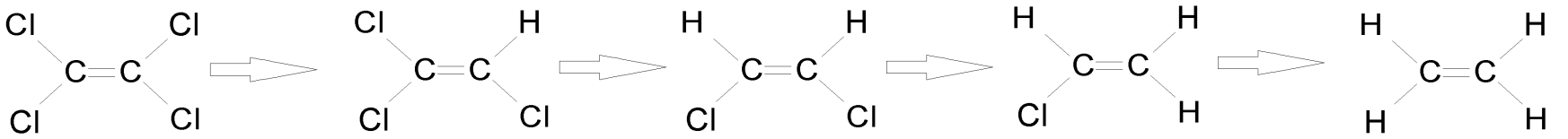
Chlorinated ethenes (PCE, TCE)

Dry cleaning, Metal working

Properties

- Heavier than water
- High water solubility
- High vapour pressure
- Forms DNAPL's
- PCE only biodegradable under anaerobic conditions

Reaction scheme with electron donor



Two stage dehalogenation process:

- First step to cis-DCE
- Second step to ethene (no accumulation of VC)

Remediation

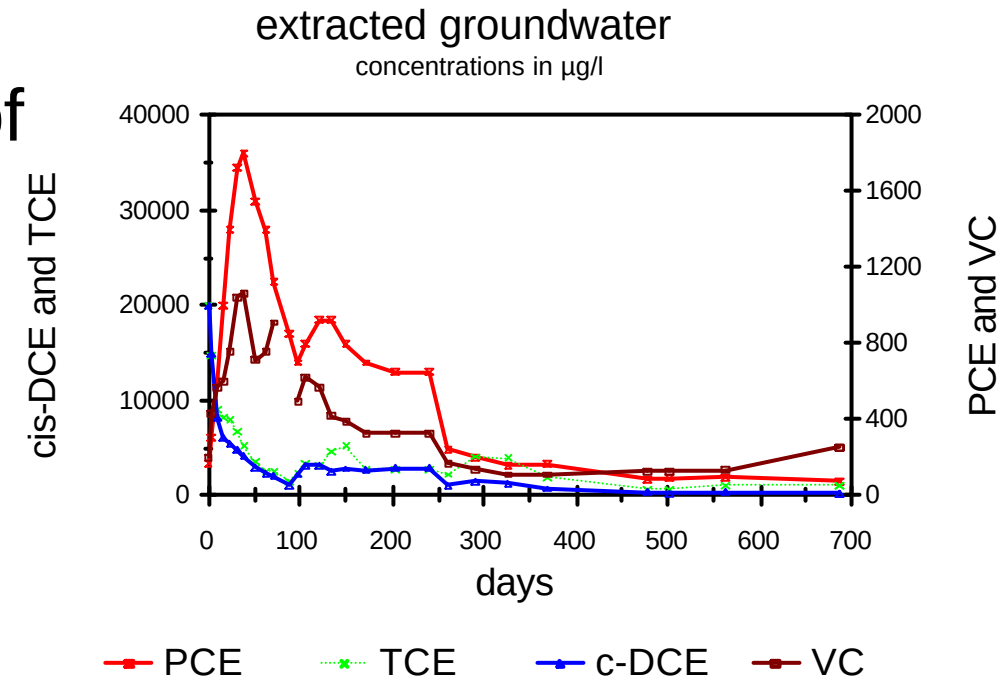
- Check on presence micro-organisms
- Anaerobic conditions
- Electron donor
- DNAPL's rate limiting

System

- Extraction /infiltration wells
- Electron donor dosing system
- Monitoring system

Results

- Rapid complete dehalogenation of PCE
- Second step electron donor dependent



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Leachate /methane

Landfill sites

Properties

- High COD, fatty acids, etc.
- Heavier than water
- Smelly
- Methane is a gas (relatively water soluble)

Remediation

- Enhance gas production /degradation of organic materials
- Circulation of leachate
- Treatment and discharge

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J. F. de Kreuk MSc. is managing director of BioSiol R & D. He has been active in research into the environmental fate of chemicals for over thirty years including soil and waste water treatment. For the last 10 years his research efforts were directed at soil treatment and the development of processes for in-situ remediation of contaminated soils.

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